OCCURRENCE, STRATIGRAPHIC DISTRIBUTION, AND ABUNDANCE OF CHITINOZOA FROM THE MIDDLE DEVONIAN COLUMBUS LIMESTONE OF OHIO[1]

ROBERT P. WRIGHT, The Department of Geology and Mineralogy, The Ohio State University, Marion, Ohio

Abstract. Chitinozoa from the Middle Devonian Columbus Limestone of central Ohio belong to eight species of the genera *Alpenachitina, Ancyrochitina, Angochitina, Conochitina, Desmochitina,* and *Eisenackitina.* Two new species, *Ancyrochitina frankeli* and *Eisenackitina robusta,* are described. The Chitinozoa occur in carbonate rocks such as mudstone, grainstone and packstone that represent well circulated open marine conditions. They are absent from dolomite which represents sediment deposited at a shallow water depositional site characterized by restricted water circulation. Comparison of the Columbus Limestone Chitinozoa with faunas from similar Middle Devonian strata in Iowa, Illinois, and Missouri indicates that the Middle Devonian Wabash Platform, located in Indiana, effectively restricted the distribution of chitinozoans in the Illinois and Appalachian Basins.

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Chitinozoa were first described in the 1930's by the German scientist A. Eisenack (1930, 1931) from Silurian glacial erratics in the Baltic region of Europe. Since that time interest in this group of extinct organic-walled microorganisms has grown in Europe and the Americas as exemplified by the recent monographic treatment of the group (Combaz *et al*, 1967; Taugourdeau *et al*, 1967). The interest of North American paleontologists in this group of fossils has grown steadily since the 1950's.

The importance of Chitinozoa is twofold. They are abundant and easily extracted from strata of Ordovician through Devonian age and, as some of the forms may have been members of the lower Paleozoic zooplankton (Chaiffetz, 1972), their biostratigraphic value is obvious. The presence of Chitinozoa in the Columbus Limestone as well as faunas from strata of similar age elsewhere in the Midwest (Urban, 1972; Urban and Newport, 1973; Legault, 1973; Wood, 1974) suggest their potential importance for the refinement of the biostratigraphy of Middle and Upper Devonian strata in North America. Second, Chitinozoa appear to be useful bathymetric indicators (Williams and Sarjeant, 1967; Gray *et al*, 1974). Laufeld (1975) has noted, in the Silurian of Gotland, Chitinozoa diversity and abundance increase away from reefoid detrital limestones in the direction of deeper water.

The dominant feature of the Middle Devonian paleogeography of Indiana, Illinois, and Ohio is now recognized as consisting of a broad shallow water carbonate shelf (Droste *et al*, 1975). That shelf, called the Wabash Platform, controlled the sedimentology of adjacent basins in Missouri, Iowa, Illinois, Michigan, and Ohio. It must have influenced the spatial and temporal distribution of the marine plankton and members of the benthic fauna. In this regard, the description of the Columbus Limestone Chitinozoa is the necessary first step in establishing the degree of Chitinozoa faunal interchange in the Illinois, Michigan, and Appalachian Basins. The purpose of this paper is to describe the occurrence, stratigraphic distribution, and abundance of Chitinozoa in the Middle Devonian Columbus Limestone in north-central Ohio.

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METHODS AND MATERIALS

Collections for this study were obtained from the Hamilton Brothers Quarry near Marion, Ohio. The Columbus Limestone is well exposed and stratigraphically complete at this locality (fig. 1). The strata were examined in detail in order to determine the depositional environments represented by the various carbonate lithofacies and to attempt to identify the environmental occurrence of the Chitinozoa.

Fresh samples were taken systematically at two-foot vertical intervals or at every change in lithology. In all, 41 samples were treated using the following techniques. Fifty grams

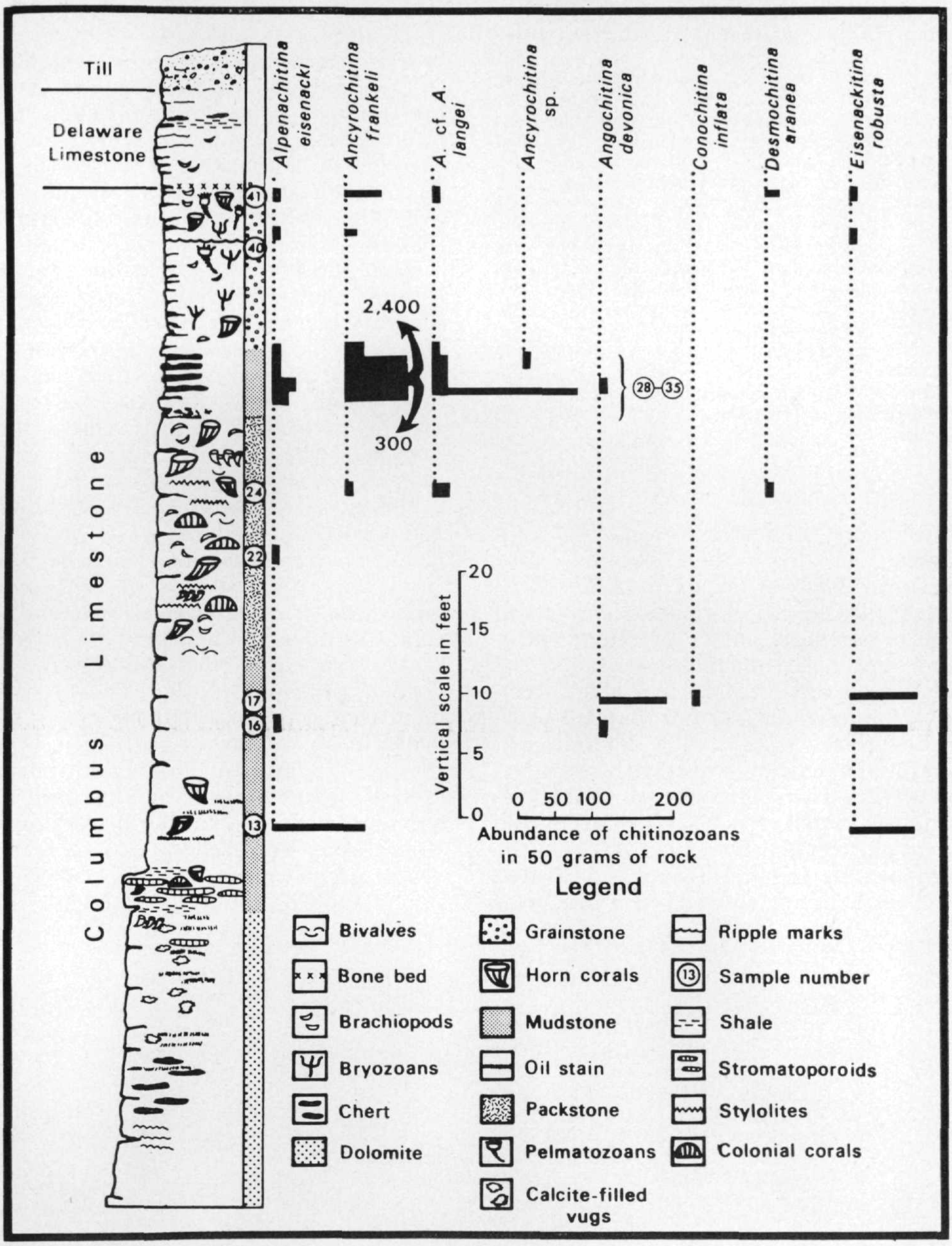

FIGURE 1. Stratigraphic section of the Columbus Limestone exposed in the Hamilton Brothers Quarry. The section shows the vertical destribution of carbonate lithofacies and Chitinozoa.

from each sample were placed in beakers and covered with concentrated HCl. After the reaction ceased, the acid was diluted and sediment washed by filling the beaker with tap water and sieved according to a procedure described by Laufeld (1974). The sieving cloth had a mesh distance of 45 microns.

After sieving and washing, the residue was poured into a beaker and treated with concentrated HF, and allowed to stand for 24 hours until the silica was digested. The acid was then diluted with water and the residue sieved, washed, and stored in small vials filled with distilled water. Identification and counts of each taxon were made and recorded. The best specimens were removed from the beakers with a finely drawn glass pipette and prepared for scanning electron microscopy. Four to six specimens were mounted on a glass coverslip using a graphite adhesive. The specimens were coated with gold in a vacuum apparatus and studied using a Cambridge S4 Stereoscan (SEM).

All specimens were deposited in the Orton Museum at The Ohio State University in Columbus, Ohio and designated with OSU numbers. SEM stubs containing the specimens are coded thusly: In 1–29, 1 = stub number, 29 = field number.

GENERAL STRATIGRAPHY AND DEPOSITIONAL FRAMEWORK

Columbus Limestone crops out in a narrow belt from the Columbus area north to Kelly's Island in Lake Erie. In central Ohio the formation consists of a lower dolomite unit and an upper limestone unit. At the Hamilton Quarry the dolomite is less than 25 feet thick, relatively unfossiliferous and banded with hydrocarbons (fig. 1). The dolomite was deposited in shallow water with restricted circulation when submergence of the low-lying weathered craton took place during Early and Middle Devonian. The overlying fossiliferous limestone was deposited in an open marine environment with good water circulation. At the Hamilton Quarry, the so-called "coral-stromatoporoid zone" is well developed, and marks the beginning of open marine conditions. The association of stromatoporoid sponges, tabulate and rugose corals that characterizes this unit represents stabilization of the mud substrate by bottom dwelling "carpeting" organisms.

The skeletal-poor mudstone above the biostrome is a low energy, below wave-base deposit (Chapel, 1975). The occurrence of the mudstone above the biostrome indicates deepening of the water over the coral-stromatoporoid studded shallow platform.

The fossiliferous packstone midway through the section records regression or shallowing of the water. The abundance of specimens of ***Brevispirifer gregarious*** as well as the appearance of other species of brachiopods, corals, molluscs, bryozoans, and pelmatozoans indicate that circulation kept the bottom relatively free of large amounts of carbonate mud that would have smothered many of the filter and suspension feeders.

The cherty mudstones near the top of the stratigraphic section do not contain large quantities of skeletal material, except Chitinozoa. The mudstones represent a semi-restricted above wave-base deposit, perhaps deposited in an environment that was somewhat lagoonal. The peaks in abundance of the Chitinozoa in the cherty mudstone indicate that the rate of sedimentation at this time was less than when the packstones and grainstones were deposited.

The grainstone in the uppermost portion of the Columbus Limestone, with its

EXPLANATION OF FIGURE 2

No. 1–6. Scanning electron micrographs of *Ancyrochitina frankeli* Wright, n. sp.
1. Paratype, OSU 32159, ×600, 4–32.
2. Paratype, OSU 32158, ×900, 4–32, high magnification showing the oral end of the specimen.
3. Paratype, OSU 32157, ×450, 4–32.
4. Paratype, OSU 32156, ×525, 3–31, note the clavate basal spine.
5. Holotype, OSU 32155, ×525, 3–31, specimen shows the long neck in proportion to the body chamber and the bifurcating neck and basal spines.
6. Paratype, OSU 32154, ×525, 3–31, note absence of neck spines.

No. 7–9. Scanning electron micrographs of *Alpenachitina eisenacki* Dunn and Miller, 1964.
7. Note the small spines at the base, OSU 32153, ×575, 2–35.
8. Specimen showing the delicate branching of the vesicle spines, OSU 32152, ×575, 2–40.
9. Note the length of the neck in comparison to the body chamber, OSU 32151, ×575, 1–29.

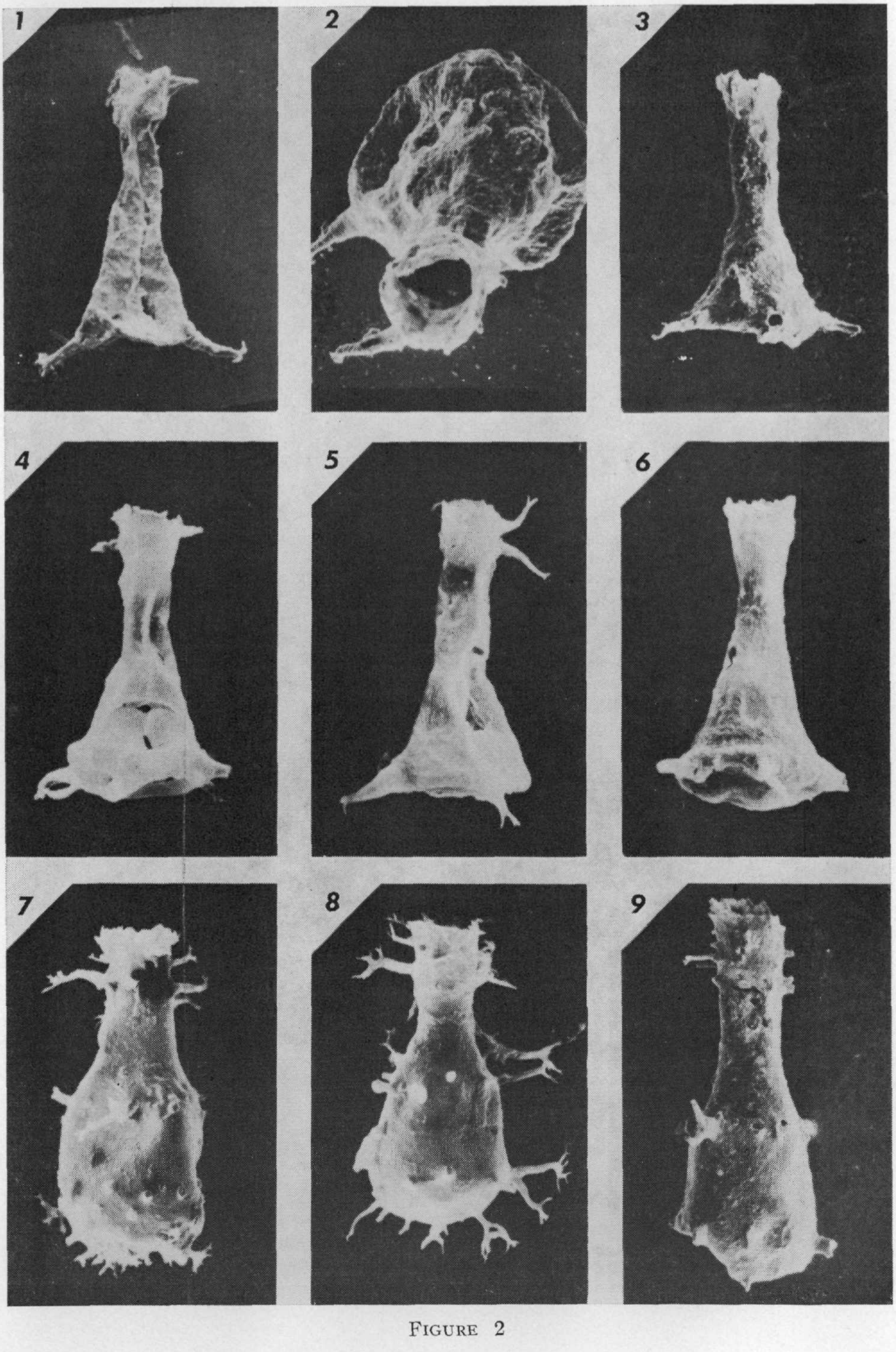

FIGURE 2

crinoidal debris, abraded ripples (Bates, 1971), and bone beds representing lag concentrations, abruptly changing to mudstone in the overlying Delaware Limestone indicates transgression and submergence.

CHITINOZOA

Representatives of six genera and eight species of Chitinozoa were collected from the Columbus Limestone. Their distribution is not random through the section as they are more abundant in the mudstones than in the grainstones and packstones. Their small numbers in the coarse-grained sediments do not appear to be a function of selective preservation, as well preserved specimens of forms with delicate spines (e.g., *Alpenachitina eisenacki*) are common in these deposits.

It is apparent that Chitinozoa are absent in the dolomite below the coral-stromatoporoid layer. Their absence was not caused by vescile destruction during dolomitization because the Chitinozoa are present and well preserved in the dolomitized mudstone immediately above the coral-stromatoporoid interval. The absence of Chitinozoa in the dolomite and first occurrence above the coral-stromatoporoid interval is interpreted as a transition from a nearshore restricted shallow water environment to an offshore, deeper water area with well circulated water.

Ancyrochitina frankeli (fig. 2) dominates the chitinozoan fauna in the cherty mudstone. The great abundance of *A. frankeli*, well over 1,000 specimens per 50 grams of rock, stands out in comparison to the relative abundance of the other species throughout the rest of the section. Cramer (1970) has suggested that an enormous increase in the abundance of Chitinozoa within just a few inches of rock may represent a planktic bloom similar to blooms in modern coastal waters. An alternative, and probably correct, explanation is that the increase in numbers of specimens is a consequence of the relatively slower sedimentation rate of the mudstone in comparison to the coarser-grained carbonates. The Columbus Limestone, by being deposited in very shallow water, precludes planktic blooms from being recorded.

The regional distribution pattern of Chitinozoa suggests that the Wabash Platform influenced their geographic distribution. *Ancyrochitina frankeli*, *Conochitina inflata*, and *Eisenackitina robusta* appear to be unique to Middle Devonian strata in Ohio and Ontario in so far as these species are not part of the chitinozoan faunas of the Cedar Valley Formation and Wapsipinicon Formation of Iowa and northwestern Illinois or the Cedar City Formation in Missouri.

Ancyrochitina frankeli and *Conochitina inflata* are known from the Silica Formation (Wood, 1974) in northeastern Ohio, the Dundee Limestone (Hill, 1975) near St. Mary's, Ontario and the Columbus Limestone as reported here. Specimens referred to as *Eisenackitina robusta* have not been reported from Middle Devonian sediments, other than the Columbus Limestone.

In spite of the apparent effectiveness of the broad shallow platform in acting as a

EXPLANATION OF FIGURE 3

No. 1–5. Scanning electron micrographs of *Desmochitina aranea* Urban, 1972.
1. Specimen shows the slight bulge at the base of the chamber, OSU 32168, ×500, 10–41.
2. Note the ornamentation of short verrucae that is characteristic of this species when the periderre is preserved, OSU 32167, ×575, 9–41.
3. Note the prominent membranous collar that is devoid of ornamentation, OSU 32166, ×575, 9–41.
4. Shows the cylindro-oval shape which is typical for the species, OSU 32165, ×575, 8–41.
5. Specimen shows the basal callus, OSU 32164, ×575, 7–41.

No. 6. Scanning electron micrograph of *Ancyrochitina* sp.
6. Note the abnormally directed basal spines, OSU 32163, ×500, 6–35.

No. 7–9. Scanning electron micrograph of *Ancyrochitina* cf. *A. langei* Sommer and van Boekel, 1964.
7. An *A. langei* type, OSU 32162, ×525, 3–31.
8. Specimen shows how the spines are unbranched and curl in an oral direction, OSU 32161, ×550, 4–29.
9. Note the appendices are attached without any connection to the vesicle interior, OSU 32160, ×500, 5–29.

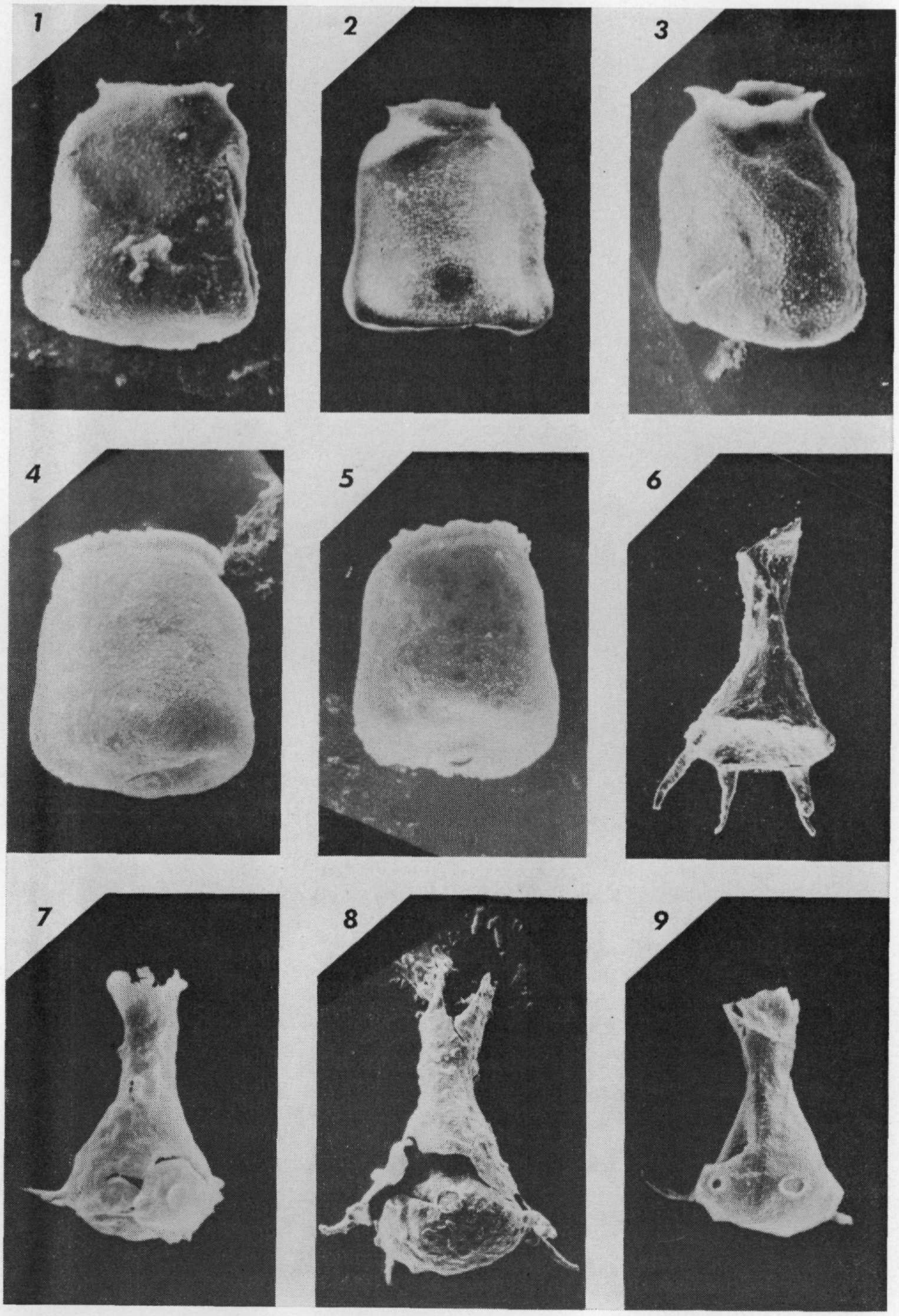

Figure 3

faunal barrier to some species in the Midwest, geographic isolation between the eastern (Ohio, Ontario, Michigan) and western (Iowa, Illinois, Missouri) portions of that platform was not complete. *Desmochitina aranea*, *Alpenachitina eisenacki*, and *Angochitina devonica* are common to Middle Devonian sediments deposited along both sides of the Wabash Platform. Mapping the distribution of chitinozoans from Middle Devonian strata in Indiana and in Illinois will help determine the degree of faunal interchange between the areas east and west of the platform and permit comparison with Chitinozoa faunas from Middle Devonian strata in Iowa, Missouri and Ontario.

Most of the species of Chitinozoa in the Columbus Limestone, except *Eisenackitina robusta*, occur in the Middle Devonian strata elsewhere in the Midwest. With my findings of *Alpenachitina eisenacki* and *Desmochitina aranea* in the Columbus Limestone, the stratigraphic range of these species is now extended to include the entire Middle Devonian. *Conochitina inflata* and *Ancyrochitina frankeli* are now known to occur in the Columbus Limestone, Dundee Limestone, and Silica Formation, representing Eifelian and early Givetian strata of the Middle Devonian in North America.

SYSTEMATIC PALEONTOLOGY

CHITINOZOA, Eisenack, 1931

Genus *Alpenachitina*
Dunn and Miller, 1964
Type species:
Alpenachitina eisenacki Dunn and Miller, 1964

Alpenachitina eisenacki Dunn and Miller, 1964
Fig. 2 (7–9)

Genus *Ancyrochitina* Eisenack, 1955
Type species:
Conochitina ancyrea Eisenack, 1931

Ancyrochitina frankeli n. sp.
Fig. 2 (1–6)

Ancyrochitina cf. *A. ancyrea* (Eisenack) (Wood, G., 1974, p. 135, pl. 7, figs. 1, 2).

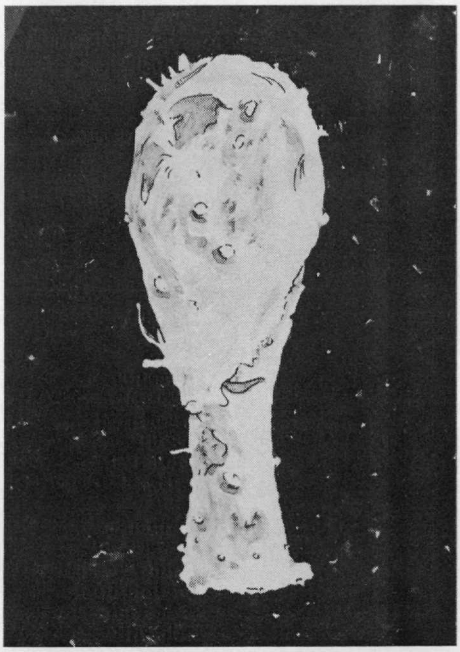

FIGURE 4. Drawing of *Angochitina devonica* showing the specimens profile and nearly circular, elevated spine attachment scars distributed randomly on the vesicle.

EXPLANATION GF FIGURE 5

No. 1–2. Scanning electron micrographs of *Conochitina inflata* Wood, 1974.
1. Note the swollen shoulder, characteristic of the species, OSU 32177, ×500, 6–17.
2. Specimen shows the swollen base of the cylindrical vesicle, OSU 32176, ×500, 12–17.

No. 3–9. Scanning electron micrograph of *Eisenackitina robusta* Wright, n. sp.
3. Paratype, OSU 32175, ×500, 12–17, heavily ornamented aboral portion of the vesicle wall and the well defined collar.
4. Paratype, OSU 32174, ×600, 11–13, the surface of this specimen is relatively smooth due to degradation of the ornamentation.
5. Paratype, OSU 32173, ×500, 10–13, note how the ornamentation is greatest on the aborally inflated portion of the vesicle.
6. Holotype, OSU 32172, ×500, 10–13, note the expanded aboral portion of the chamber and the coarsely verrucate ornamentation which characterizes this species.
7. Paratype, OSU 32171, ×575, 13–16.
8. Paratype, OSU 32170, ×575, 6–16, specimen shows the prominent basal callus.
9. Paratype, OSU 32169, ×450, 11–16, note the ornamentation.

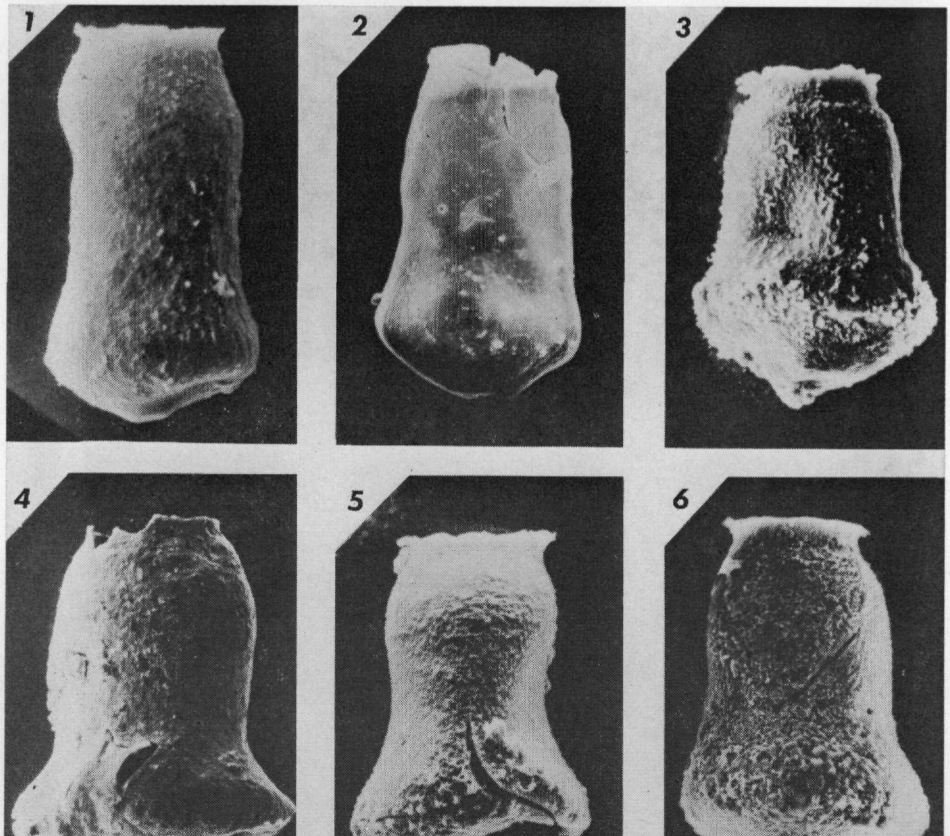

FIGURE 5

Derivation of name: In honor of Dr. Larry Frankel, paleontologist at the University of Connecticut.

Description: The vesicle is cylindro-conical to pyriform with a flat or slightly convex base. Vesicle collapse results in a convex base and a compressed neck and body chamber. Ornamentation consists of basal and neck spines, both of which vary in number, size, and shape. Basal spines are in most cases 4 to 6 in number, but may be up to 8, are hollow, long, and commonly delicately bifurcated at their tips. Several specimens possess clavate spines. Spines may be thick or thin and both types may occur on the same specimen. The spines on the neck vary in shape from short, thick spikes to long delicate simple or bifurcating ones. A collar is often distinguishable. The surface of the vesicle is usually smooth, however some specimens have a finely verrucate ornamentation.

Dimensions: Population from the type stratum in microns: length (excel.) 120–195 (holotype 140), width (exl.) 60–100 (holotype 66), maximum length of basal spines 30 (holotype 30).

Types: Holotype OSU 32155, Paratypes OSU 32154, 32156, 32157, 32158, 32159.

Type stratum and locality: Cherty limestone (sample 31), forty feet above the "coral-stromatoporoid zone," the Columbus Limestone, Hamilton Brothers Lime and Stone Quarry, Marion, Ohio.

Discussion: Ancyrochitina frankeli is the most abundant chitinozoan species in The Columbus Limestone. More than 3,000 specimens were examined. Although the vesicle morphology is somewhat variable, the species is distinct in its pyriform to cylindro-conical shape which resembles that of *Ancyrochitina ancyrea*. *A. ancyrea* is reported to have a long stratigraphic range (Ordovician through Devonian) and to be a cosmopolitan form. Laufeld (1974) has restricted the scope of the species and reports it as characteristic of the Silurian. Specimens of *A. ancyrea* reported from the Devonian may not be conspecific with the *A. ancyrea* of the Silurian. Pichler's (1971) figured specimens of *A. ancyrea* from the Devonian of the Eifel Synclinorium, West Germany, and those reported by Taugourdeau (1965) from France possess sharply conical body chambers with a shorter neck than the Silurian forms from Gotland. Representatives of *A. frankeli* from the Eifelian and Givetian of North America exhibit a different silhouette than do the specimens illustrated by Pichler and Taugourdeau in that the body chamber is not as sharply conical and the neck much longer in proportion to the body chamber. In addition, the basal spines of *A. frankeli* typically bifrucate at their distal ends, whereas those of Pichler's specimens are multibranched. Individuals of *A. frankeli* have broadly based and often clavate basal spines and, when present, long delicate neck spines which distinguish them from the Gotland specimens (Laufeld, 1974). *A. frankeli*, therefore, is a distinct species characteristic of the Middle Devonian. The form has not been reported from any other North American localities outside Ontario (Hill, 1975) and northern Ohio (Wood, 1974).

Ancyrochitina cf.
A. langei Sommer and van Boekel, 1964
Fig. 3 (7–9)

Ancyrochitina sp.
Fig. 3 (6)

Genus *Angochitina* Eisenack, 1931
Type species:
Angochitina echinata Eisenack, 1931
Angochitina devonica Eisenack, 1955
Fig. 4

Genus *Conochitina* Eisenack, 1931
Type species:
Conochitina claviformis Eisenack, 1931
Conochitina inflata Wood, 1974
Fig. 5 (1–2)

Genus *Desmochitina* Eisenack, 1931
Type species:
Desmochitina nodosa Eisenack, 1931
Desmochitina aranea Urban, 1972
Fig. 3 (1–5)

Genus *Eisenackitina* Jansonius, 1964
Type species:
Eisenackitina castor Jansonius, 1964
Eisenackitina robusta n. sp.
Fig. 5 (3–9)

Derivation of name: Latin *robusta,*

physically strong and powerful referring to the general appearance of the vesicle.

Description: Vesicle is subconical to subcylindrical with sides that vary from slightly to strongly convex. The shoulder is distinct; the neck is reduced to a narrow collar that flares in oral direction. The aboral portion of the chamber expands prominently at the basal edge; the base is convex and possesses a prominent basal callus. The surface of the vesicle has a verrucate ornamentation and in some specimens the swollen basal edge is more heavily verrucate than the remaining chamber wall. The fine verrucae on a very few specimens may be a result of degradation of the vesicle surface from a more verrucate condition.

Dimensions: Population from the type strata in microns: length (excl.) 160–170 (holotype 166), width (excl.) 110–132 (holotype 110).

Types: Holotype OSU 32172, Paratypes OSU 32169, 32170, 32171, 32173, 32174, 32175.

Type stratum and locality: Dolomitized mudstone (Sample 13), five feet above the "coral-stromatoporoid zone," the Columbus Limestone, Hamilton Brothers Lime and Stone Quarry, Marion, Ohio.

Discussion: This species is tentatively assigned to the genus *Eisenackitina*. The elongate shape of the vesicle is typical of *Eisenackitina* and the distinct collar is similar to that found in specimens of *E. canadensis* (Legault, 1973) and *E. sylvaniensis* (Wood, 1974). Legault (1973, p. 91, pl. 8, figs. 3, 9) has noted bulging at the basal edge in specimens which she has referred to as *Eisenackitina*. The number of characteristics of *E. robusta* that do fit well with the description of the genus justify the reference of this species, at least tentatively, to *Eisenackitina*.

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